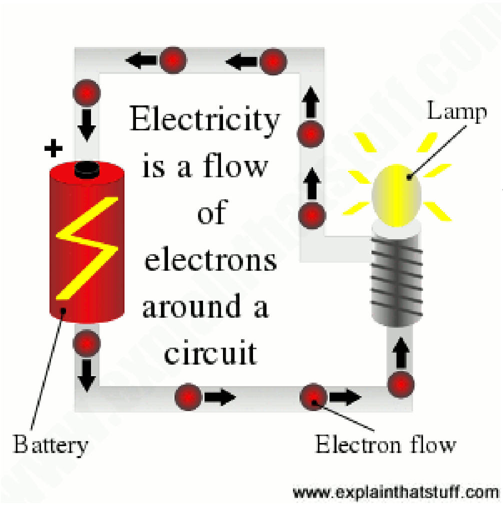
Part 1: Basic Electronics and Components



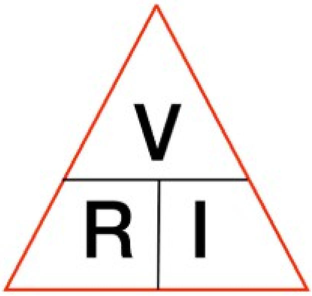
...and interesting stuff happens when it passes through things!

Voltage (V): measured in *Volts*, is the difference in charge between two points, such as the positive and negative leads on a battery.

Current (I): measured in *Amperes*, is the rate of electric flow.

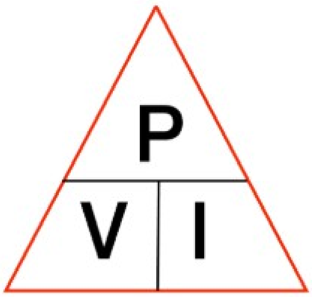
Resistance (R): measured in *Ohms*, is opposition to the flow of current.

Power (P): measured in *Watts*, is the rate of transfer of electrical energy...or, how much it hurts to get zapped!



$$\frac{V}{R} = I \qquad \frac{V}{I} = R$$

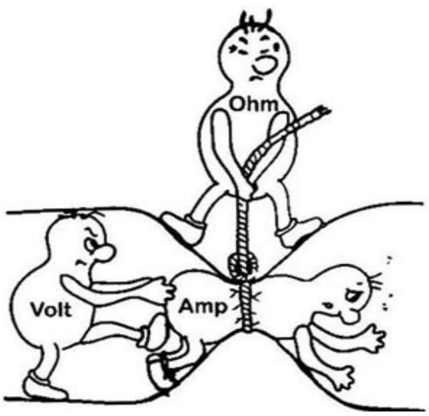
$$R \times I = V$$



$$\frac{P}{V} = I \qquad \frac{P}{I} = V$$

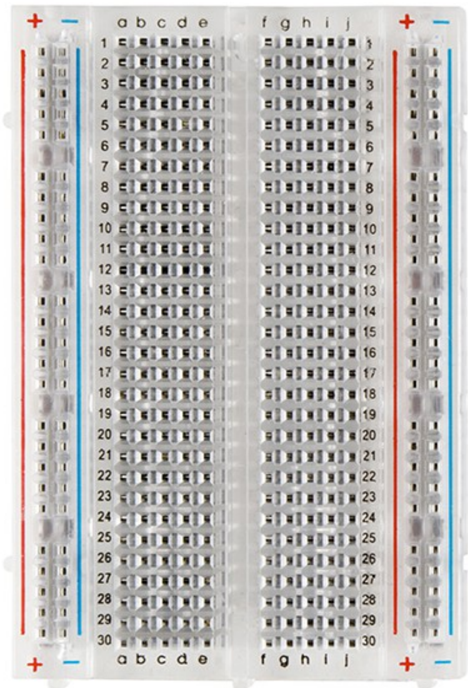
$$V \times I = P$$

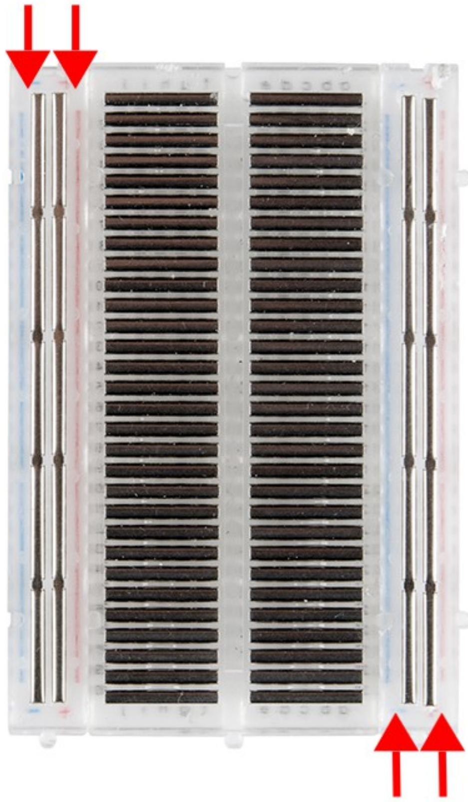
Voltage, current, resistance, and power all relate to each other following the above equations (the triangles make the relationships easier to remember). The important thing to know is that (almost) ***<u>every circuit you build needs a resistor</u>*** or it will draw lots of power and be a potential danger to yourself and your equipment!!!

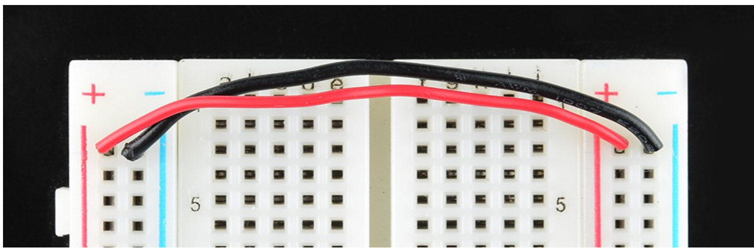


Another way to visualize the relationship between voltage, current, and resistance...

Breadboards are used to quickly prototype circuits because they let you connect components together simply by pushing wire leads into holes. The image to the left is what a breadboard looks like from the outside, the image to the right shows what a breadboard looks like on the inside. The black bars on the right image are continuous pieces of metal connecting sets of holes together. So if you connect a component to row 1, column a, and another component to row 1, column e, then those components are connected.







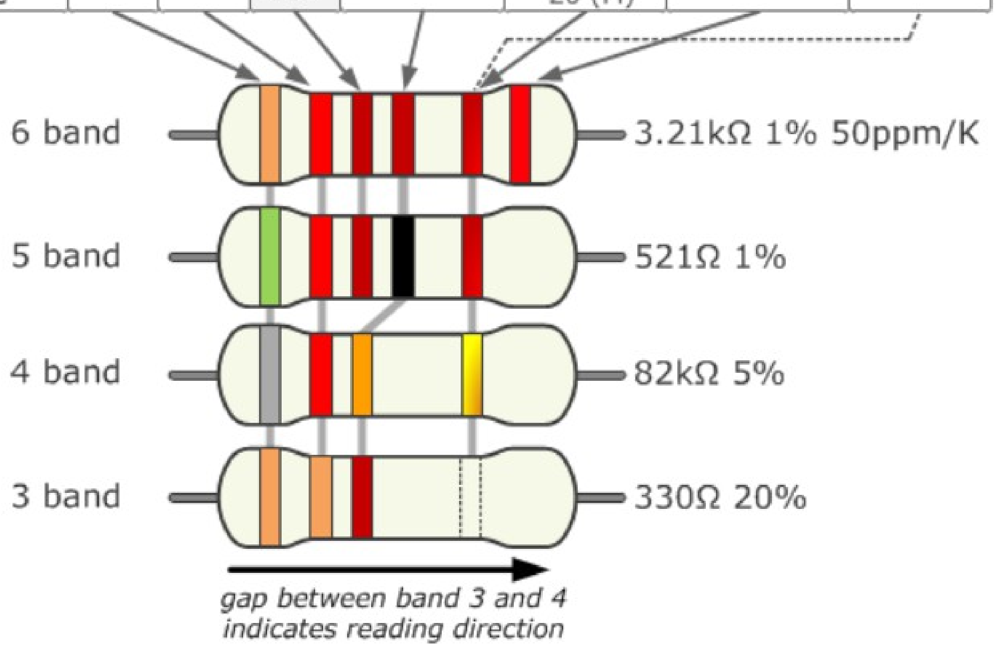
To make the best use of your breadboard, I recommend connecting the left power rail (red) with the right power rail and the left ground rail (blue) with the right ground rail with jumper cables. Then connect either power rail to the positive side of an external power supply (like a battery) and the ground rail to ground or to the negative side of an external power supply.

Ground: If you think of electicity as water moving down a hill, ground is like sea level. It's a point of reference for measuring voltage (the voltage at any point in your circuit is the difference in charge between that point and ground) and it's where the electricity goes when you are done with it. It's called "ground" because for many circuits, ground is literally the ground of the Earth, which has the effect of dissipating and neutralizing any electricity you throw at it because it is big.

If you are using a new kit, your resistors are labelled. If not, you can figure out the value of a resistor with this guide. For this class, it is not important to be precise about resistor values, anything between 100 ohm and 1,000 ohm should work fine.

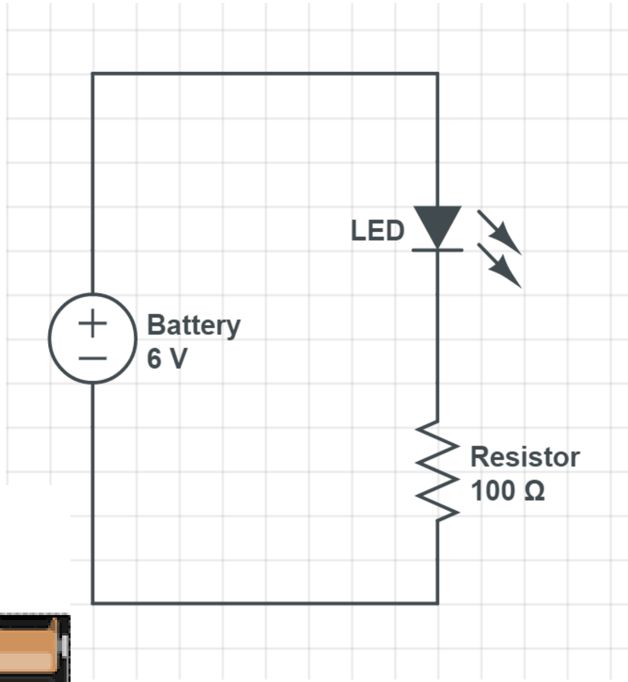
www.resistorguide.com

Color	Signficant figures			Multiply	Tolerance (%)	Temp. Coeff. (ppm/K)	Fail Rate (%)
black	0	0	0	x 1		250 (U)	
brown	1	1	1	x 10	1 (F)	100 (S)	1
red	2	2	2	x 100	2 (G)	50 (R)	0.1
orange	3	3	3	x 1K		15 (P)	0.01
yellow	4	4	4	x 10K		25 (Q)	0.001
green	5	5	5	x 100K	0.5 (D)	20 (Z)	
blue	6	6	6	x 1M	0.25 (C)	10 (Z)	
violet	7	7	7	x 10M	0.1 (B)	5 (M)	
grey	8	8	8	x 100M	0.05 (A)	1(K)	
white	9	9	9	x 1G			
gold			3th digit only for 5 and 6 bands	x 0.1	5 (J)		
silver				x 0.01	10 (K)		
none					20 (M)		

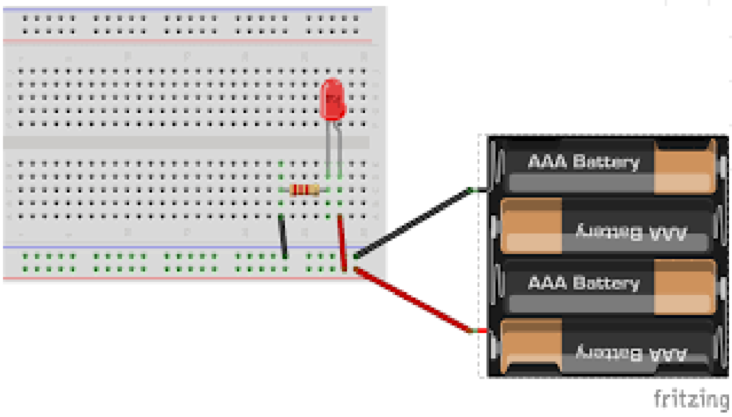


Part 2: Create a Simple Circuit

The image to the right is a *schematic*. A schematic contains the minimum information needed to build a circuit.

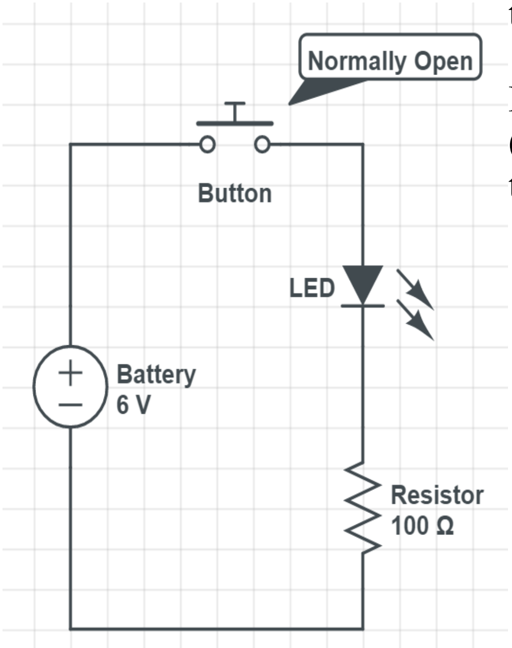


The image below is a *wiring diagram*. Wiring diagrams have more detail than schematics and can be easier to understand.

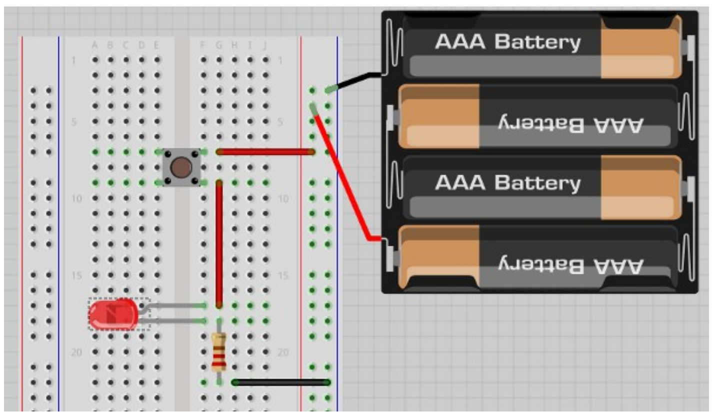


These two images are of the *same circuit*, they are only drawn in different ways. It is useful to be able to mentally translate between wiring schematics and wiring diagrams.

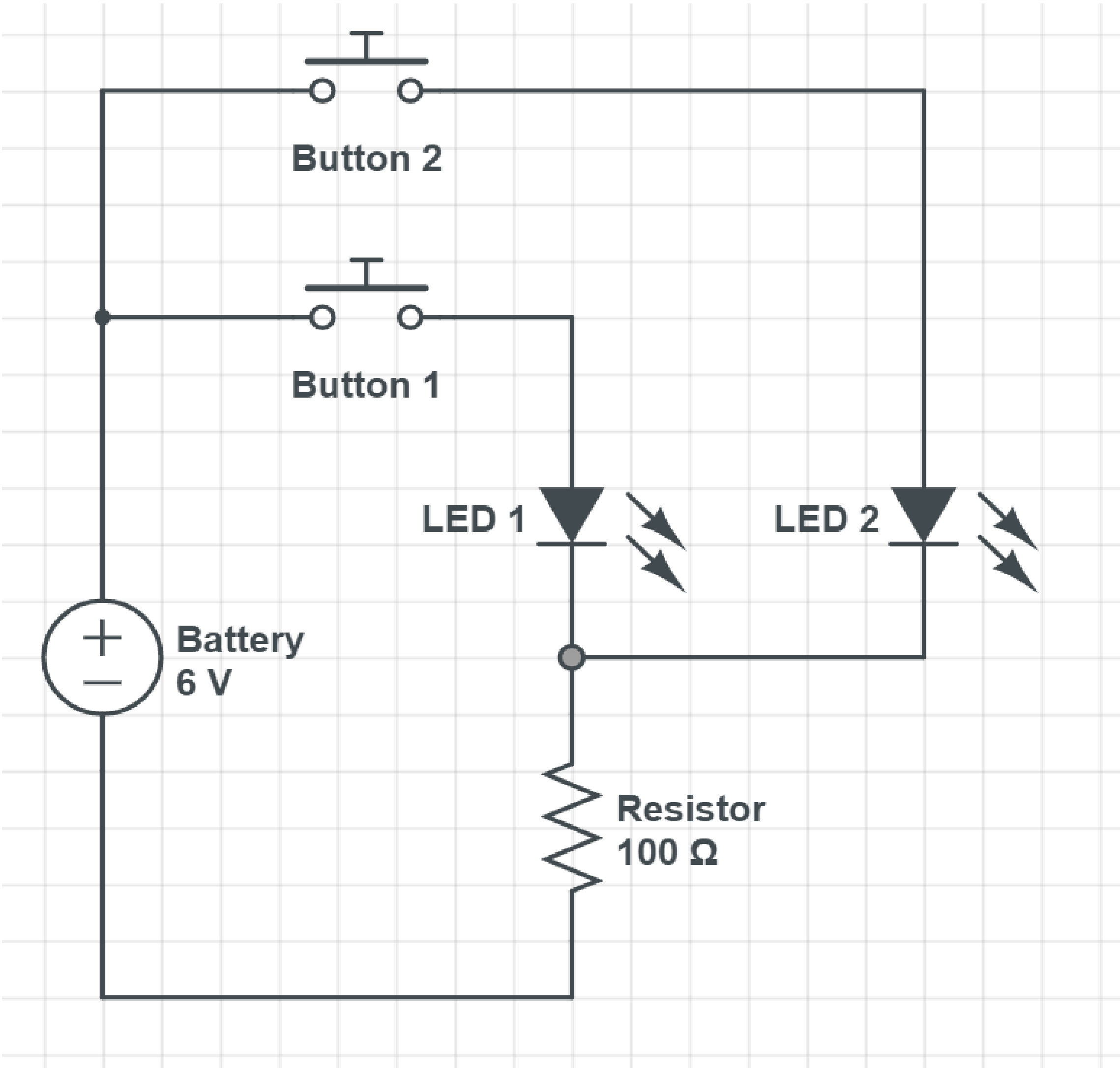
Now let's make it more interesting by adding a button. The light should now turn off, then turn on when the button is pressed.



Here is the schematic (left) and wiring diagram (right). Turn the button so that it can reach over the gap in the middle of the breadboard.

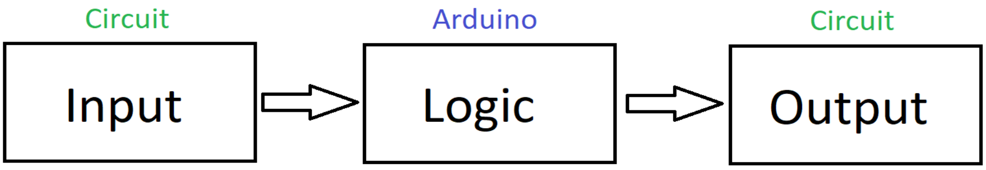


Now expand your circuit so it contains two buttons, each controlling its own LED. This time, however, I am only giving you the schematic—you will need to figure out the actual wiring for yourself...



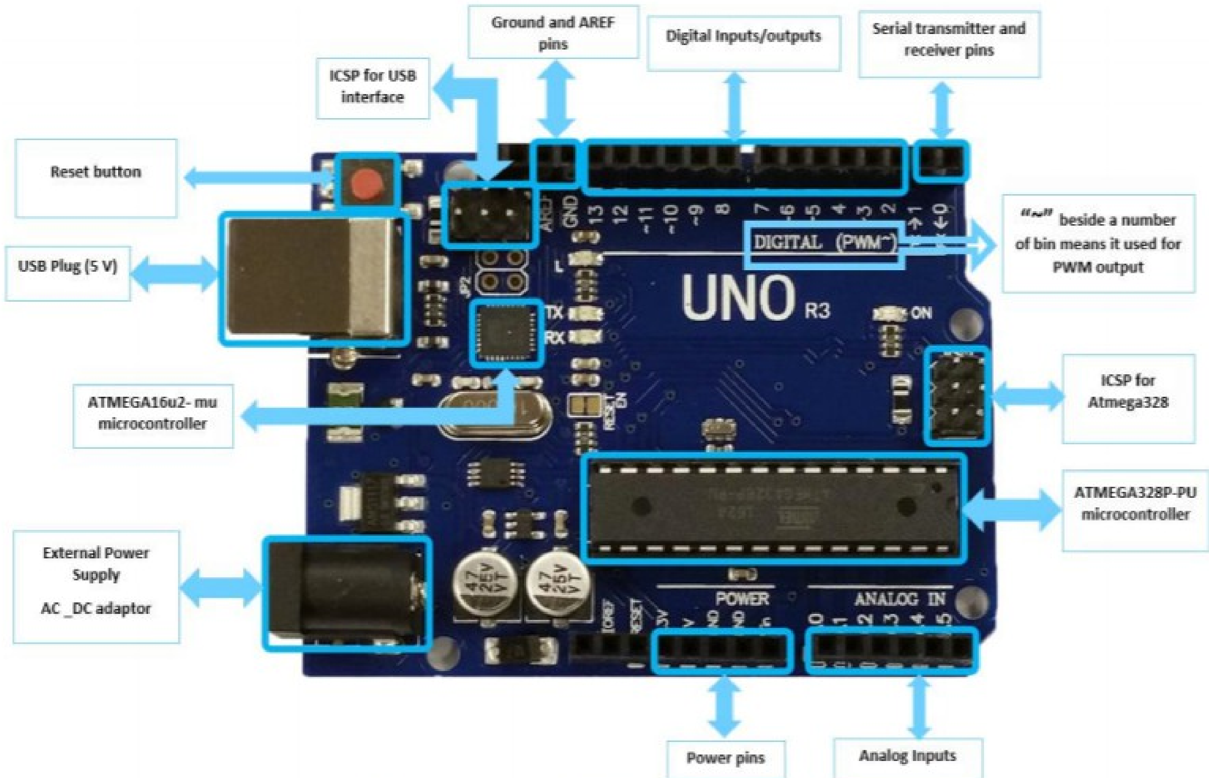
Part 3: Connecting an Arduino

An electrical device can be thought of as having three parts: input, logic, and output. In our previous circuit, for example, the button was our input, the LED was the output, and there wasn't really any logic because it was just a simple light switch. As our circuits get more complex, most of that complexity will be in the logic.



The Arduino allows us to program the logic of our device—how inputs are processed and translated into outputs—as computer code. Writing code isn't always easy, but it's MUCH easier than physically wiring transistors and specialized logic chips!

The below image is an Arduino. There's a lot going on, but we will only be using a few parts in this lesson series.



Programming an Arduino involves the following steps:

1) Connect the Arduino to a computer via the USB port.
2) Create a Sketch in Arduino (program your logic) and verify there are no errors
3) Connect the inputs and outputs of your device to the appropriate pin slots on the Arduino (which slots you are using will be controlled by your code)
4) Upload your sketch onto the device

When your device works the way you want and you are ready to show off your prototype, you can unplug the USB connection and power the Arduino with a battery via the External Power Supply. If you have a program running on your Arduino and you want it to start over from the beginning, press the red reset button.

If you are finished prototyping and want to try turning it into a wearable device, you can remove the ATMEGA328P-PU microcontroller chip from the Arduino (and replace it with another so you can continue making new things), and solder it, along with the other components in your circuit onto a protoboard. The ATMEGA chip is what actually stores/runs your program (the rest of the Arduino is basically a convenient interface). If that works and you want to convert your device into a potentially sellable product, the next step is to design a PCB, which basically eliminates most soldering, and also consider downgrading from an ATMEGA chip into something smaller, cheaper, and with functionality limited to your needs. After that, you are ready to start looking for vendors to help with mass production! Soldering, PCBs, and manufacturing, however, are beyond the scope of this course and are only mentioned here to give you an overview of the process of how electronic devices in the real world are made.

The rest of the course content is programming-focused and covered in a video series on my YouTube channel. To find the videos, go to YouTube and search for "Playcraft Toys and Games", then look for the "SA – Arduino" playlist.

The below schematic covers a basic setup for connecting your Arduino to your electronic device and is referenced in the video series. When you have your project working, test your understanding of the design by adding additional input and output channels or by replacing the button, LED, or speaker with other sensors and displays.